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Effect of Some Land Preparation and Sowing Methods on Wheat Production in the Lower Terraces of Northern State of Sudan (Dongola area)

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Abstract— *Wheat production in large areas mainly depends on efficient use and managing of mechanized production systems. The present study was carried out on the lower terraces of the northern state of Sudan, to study the effects of some tillage practices and sowing methods on some soil and plant parameters and crop yield. The experiment was arranged in strip plot design and all treatments were randomly distributed in each of three replicates. The treatments included, three tillage treatments (Disc ploughing, heavy disc harrowing and Zero tillage), two sowing methods (manual broadcasting with ridging and Seed drilling). The results showed that, the disc plough implement recorded the highest slippage (8.9%), field efficiency (70.4%) and fuel consumption rate (15.1 L/ha), while the highest field capacity was recorded by the seed drill machine. The effect of different treatments on soil moisture content at the different depths showed that, the disc ploughing treatment recorded the highest average moisture contents (21.49%) followed by the heavy disc harrowing (20.50%) and then zero tillage (19.04%), Duncan's Multiple Range Test showed that, the differences between treatments effect was significant in the first season and insignificant in the second season. The trend was increased moisture content (db%) with increased soil depth and then decreased. The disc ploughing treatment recorded the highest average plant population, grain yield, biomass and harvest index as, 481 plants/m^2, 4.11 ton/ha, 13.6 ton/ha and 30% respectively. It can be concluded that disc ploughing treatment with any method of sowing can be used for higher production of wheat in the lower terraces of Dongola area, the northern state of Sudan.*

Keywords— *Wheat, heavy disc, zero tillage, biomass, Dongola.*

I. Introduction

Wheat is one of the most important food crops, It almost comes the third most-produced cereal after maize and rice. It is grown on about 220 million hectares worldwide, covering more land area than any other crop. Major wheat producing countries include China, India, USA, Russia and France [1]. In the Sudan, wheat production is mainly in Gezira scheme, the Northern and Nile States in addition to little areas in Rahad and New Halfa schemes. Production of wheat is insufficient to meet growing needs and imports attempt to cover the deficit because Sudan consumed 2.75 million metric tons of wheat in 2016, and only produced 456000 Tones [2]. The Northern State environment is the most suitable for wheat production and this is mainly attributed to the relatively suitable climate, fertile soils, expert farmers and availability of water and some infrastructures. The demand for wheat in the Sudan gradually increased from a little over 220,000 tons in 1970/1971 to over 800,000 tons in 1990/1991 [3] to 1,237,400 tons in 2000 [4] and that is due to urbanization and increasing population. Recently the Sudan government was planned a comprehensive program in the Northern State and other schemes to reach Sudan self-sufficiency in wheat production via vertical and horizontal expansion by rehabilitation of the existing agricultural schemes and construction of new ones. This should depend mainly on mechanized farming and usage of modern agricultural technical packages such as improved seeds, fertilizers, insecticides and mechanized services. The first use of machinery in the Northern State was in 1940s [5], and gradually mechanized services extended to cover a wide zone and the tractor becomes a vital machine in the farms used for tillage and other field purposes. This is mainly on the upper terrace, which are estimated as many hundreds of thousands of feddans, which is moderately suitable for agricultural production. Wheat production in large areas will depend upon mechanized production systems efficiently used and managed. Special attention should be given during the selection of the appropriate machine for proper land preparation and suitable sowing methods for high and profitable crop yield. A study of the effect of seeding machines included seed drill and wide level disc and two rates (95 and 145 kg/ha) on wheat yield was conducted at Gezira and Rahad [6], [7]. The results showed no significant yield differences between the treatments. Some research work was done worldwide and, in the Sudan, to study the adaptation and wheat yield in irrigated schemes ([8], [9], [10]). In the Northern State some studies were carried out for land preparation, sowing method and economics of wheat crop in the upper terraces [11], [12], but it needs more elaboration and studies for confirming or evaluating some tillage findings. The present study is to achieve the following objectives:

1. To study the effects of some tillage practices on some soil and plant parameters.
2. To investigate the effects of some sowing methods on the final crop yield, biomass yield and harvest index.

II. Materials and Methods

2.1. Location and Climate

The experiment was carried out at Dongola Agricultural Research Station Farm. The area of the experiment was 3600

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m^2 (0.86 fed.), and the soil is classified as sandy clay. The physical and chemical properties of the site soil are given in Table (1). Climate in the Northern State is desert, arid cold in winter and sun shining with high temperature in summer. The average annual rainfall is less than 100 mm. The air temperatures range from a minimum of 5° C in January to a maximum of 47° C in June. Humidity is less than 20% [13].

2.2 Experimental Equipments:

A Fiat tractor model (70 – 66) 70 HP, was used for pulling implements. The specification of the tractor used is given in Table 2.

A disc plough, a trailed heavy offset disc harrow and scraper were used to carry out the experimental treatments for land preparation. A seed drill machine and a ridger were used for sowing practices. The specifications of each implement used are given in Table (3).

Plastic tape (50 meters) long, Stopwatch, Ranging poles, Steel pegs f Measuring tape of three-meter length, Spring dial balance, Graduated container, a fuel container, a graduated scale (ruler) 30 cm long, an auger and a meter square steel shape.

TABLE 1. Some physical and chemical properties of the experimental soil

Soil depth Cm	Mechanical analysis (%) Sand	Silt	Clay	pH	EC_e dS/m	SAR	Bulk density gm/cm^3
0 – 20	59.1	11.8	29.1	8.4	1.7	7.0	1.10
20 – 40	48.0	20.8	31.2	8.4	6.9	11.0	1.18
40 – 60	44.0	10.0	46.0	8.5	12.1	21.4	1.06
60 – 80	38.0	13.0	49.0	8.6	13.0	24.3	1.03
80 – 100	41.0	08.0	51.0	8.6	12.7	25.7	1.08

TABLE 2. Specification of the tractor used.

Item	Specification
Type of tractor	FIAT “Italy”
Model	70 – 66 model ZD70
Engine fuel	Diesel
Cooling system	Water cooling, with pressurized radiator.
Horse power (HP)	70 HP.
Lubricating system	Forced lubricating by gear pump.
Front, Rear tires size	750 / 16, 13.6/ 12 – 38
Engine (RPM)	2500
Weight	2960 kg

TABLE 3. Different tillage system (parameters of implements)

Description	Model	No. of units	Width of cut (m)	Working depth (cm)
Disc plough	Nardi Italy	3 disc	0.72	24
Heavy offset disc harrow	Barazil (Boam)	14 disc (7+7)	1.5	20
Ridger	Nardi	4	1.6	12
Seed drill	Nardi	13 (7+6)	1.8	0.7
Scraper	Nardi		1.4	

2.3 Experimental Area and Design

A total area of 3600 m^2 (90m× 40m) was selected and divided into three plots (tillage system) and two sub-plots for sowing methods and each replicated three times, giving a total of eighteen plots. The size of each plot was 120 m^2 (12 X 10m). The spaces between the plots were two meters in width, one-meter length, and the spacing between replicates was two meters. Actual cultivated area was 2280 m^2 (120 X 24m). The layout of the experiment was arranged in strip plot design in which all treatments were randomly distributed in each replicate. The randomization was done from the low land to the upper land and the treatments were included, three tillage treatments:

1. Disc plough followed by leveling.
2. Heavy disc harrow followed by leveling.
3. Zero tillage (no tillage) as control

- Two sowing methods include: -

1. Manual broadcasting followed by ridging.
2. Seed drill machine

2.4 Crop Husbandry

Super phosphate fertilizer was used at a rate of 40 kg/fed in one dose before sowing. Urea fertilizer was used at a rate of 80 kg/fed in two doses. The first one of 40 kg/fedat the second irrigation, while the second dose of 40 kg/fed was given at the fourth irrigation. WadiElneil was the crop variety used in both seasons at a rate of 60 kg/fed. Sowing dates in both seasons were 20 Oct. and 10 Nov. Irrigation water was added according to crop water requirement in Dongola area (Table 4).

TABLE 4. Water requirement for wheat in Dongola area

Month	E.T.P. (mm/day)	Kc	E.Tcrop (mm/day)	IR mm/day	IR m^3/feddan
December	3.47	0.2	2.78	4.0	504.0
January	3.64	1.2	4.37	6.2	781.2
February	4.32	1.1	4.75	6.8	856.8
March	5.79	1.0	5.79	8.3	697.2

Kc = crop factor data
ETP = Daily rate of potential evapotranspiration.
ETcrop = crop water requirement. IR = irrigation water requirement.

2.5 Measurement of Parameters

1. Measurement of field efficiency and capacity

The field efficiency (F.E) was calculated as follows.

$$F.E = \frac{\text{Productive time}}{\text{Total time}} \times 100$$

The effective field capacity (E.F.C) was calculated as follows:

$$E.F.C = \frac{\text{Speed (km / hr)} \times \text{effective width of cut (cm)} \times \text{field efficiency}}{C.F}$$

Where, C.F = Conversion factor for (ha = 10, acre = 8.25, feddan = 8.33)

2. Fuel consumption rate measurement

The fuel consumption rate was calculated according to [14] as follows:

$$\text{Fuel consumption rate (Li / ha)} = \frac{\text{Reading of the cylinder (Li)}}{\text{Plot area (ha)}}$$

3. Measurement of wheel slippage:

The slippage of rear wheel of the tractor linked with different implements was measured as follows:

$$\text{Slippage \%} = \frac{D_1 - D_2}{D_1} \text{ X } 100$$

Where D_1 = Distance without load
D_2 = Distance with load

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4. Soil moisture content

Samples of soil were taken before treatment, at each irrigation and at harvest from five depths (0 – 20, 20 – 40, 40 – 60, 60 – 80 and 80 – 100 cm). The Soil moisture content percent was calculated as follows:

$$\text{Soil moisture content} = \frac{W1 - W2}{W2} \times 100$$

Where: w_1 = wet sample weight in gms, W_2 = dry sample weight in gms

5. Infiltration rate measurement

A double ring infiltrometer was used to measure the infiltration rate of water into the soil. The inner cylinder was (30 cm) in diameter and (25 cm) in length, while the outer one was (60 cm) in diameter and (30 cm) in length. The procedure described by [15] was followed.

Infiltration rate (I) and elapsed time (t) were related by the following equation: $I = Kt^n$

Where: I = accumulated infiltration (cm) in time (minutes).

t = elapsed time (minutes), n and K are characteristic constant.

6. Plant height and population

At age of 25 days from the first irrigation, three samples were selected from each treatment in each replicate. In these samples, the plant heights were measured and the average was taken to represent plant height for each treatment. To determine plant population, square metal steel was used. it was thrown randomly over plants in each plot, at plant age 85 days from the first irrigation. The samples were taken from each plot, and plant population per meter square was determined.

7. Total grain and biological yields (ton/ha) and harvest index

The grain yield (ton/ha) was calculated by cutting an area of $15m^2$ randomly from each plot when the crop was completely matured. The crop material from each plot threshed, cleaned manually and weighed.

$$\text{Grain yield (ton/ha)} = \frac{W\ kg \times 10000}{15m^2 \times 1000}$$

The weight of samples harvested from the 15 m^2 area in each plot before threshing was recorded as total biomass (ton/ha).

$$\text{Total biological weight (biomass) ton / ha} = \frac{\text{Sample weight} \times 10000}{15\ m^2 \times 1000}$$

The harvest index is a percentage of total biomass. It was calculated for each treatment as follows:

$$\text{Harvest index (\%)} = \frac{\text{Final grain yield}}{\text{Total biomass}} \times 100$$

III. Results and Discussion

Tillage Implements Performance Parameters

The results showed that, the highest field efficiency was recorded by the disc plough (70.4%) while the highest field capacity recorded by the seed drill. The heavy disc harrow recorded lower field efficiency (61.9%) and effective field capacity (0.22 ha/hr) (Table 5). This could be due to lower forward speed and greater time loss in turnings. The disc plough recorded the highest slippage (8.9%) while the lowest slippage value was recorded by the seed drill (2.2%). The higher value recorded by the disc plough could be due to the deep working depth (22cm). The higher fuel consumption rate in (Li/ha) was recorded by the disc plough (15.1 L/ha) followed by the heavy disc harrow (9.8 L/ha). This result obtained by the disc plough could be due to its long time taken in the field and the highest slippage value recorded and lower effective field capacity. These results agreed with the finding of [16] and [17].

TABLE 5. Performance parameters of implements used in the experiment

Implement description	Width of cut (m)	Depth of cut(m)	F.E. (%)	E.F.C (ha/hr)	F.C. (L/ha	Slippage (%)
Disc plough	0.78	22	70.4	0.29	15.7	8.9
Heavy disc harrow	1.5	18	61.9	0.22	9.8	6.6
Ridger	1.6	12	69.8	0.35	5.9	9.4
Seed drill	1.8	7	62.6	0.75	5.04	2.2
Scraper	1.5	-	60.0	0.22	2.1	4.44

Effect of Tillage Treatments on Soil Moisture Content and Infiltration Rate

The soil moisture content (db%) distribution was generally affected by the tillage treatments for the two seasons. The trend was increased moisture content (db%) with increased depth and then decreased (table 6). These results were in line with that of [18] and [19]. At all irrigations, the highest average soil moisture content (db%) was recorded by the disc ploughing tillage treatment (20.75%) followed by the heavy disc harrow (19.76%) and the no-tillage treatment (18.74%). The effect of different treatments on soil moisture content at the different depths showed significant differences for the two seasons except between the disc plough and heavy disc harrow treatments in some depths (table 6).

TABLE 6. Effect of tillage and sowing method on soil moisture content (db%), average of two seasons.

Tillage/depth	0 – 20	20 – 40	40 – 60	60 – 80	80 – 100	Mean
P1	16.82^{e}	19.64^{f}	22.72^{g}	23.11^{h}	21.48^{i}	20.75^{a}
P2	15.68^{j}	19.05^{f}	21.32^{i}	22.41^{g}	20.32^{k}	19.76^{b}
P3	14.31^{l}	18.65^{f}	20.4^{k}	21.05^{i}	19.32^{f}	18.74^{c}
Mean	15.6^{a}	19.11^{b}	21.48^{c}	22.19^{d}	20.37^{c}	

Means followed by the same letter(s) are not significantly different at alpha = 0.05 according to Duncan's Multiple Range Test (DMRT).

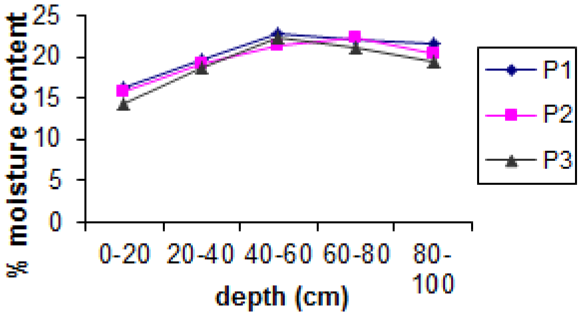

Fig. (1). Effect of tillage on soil moisture content average of two seasons

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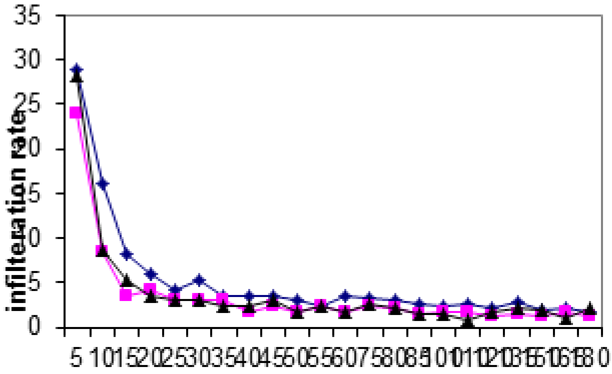

Fig. 2 Effect of tillage system on soil infilteration rate (at harvest).

The results of effect of tillage treatment on soil moisture content (db%) before irrigation in two seasons is shown in figure (1). The analysis of variance for soil moisture content (db%) and the multiple range test showed significant differences between the treatments effect with depth in the two seasons (table 6). It was clearly noticed that average values of soil moisture content for different tillage treatments at different tested depths were greater before harvesting than those results obtained before irrigation. The results are in agreement with the findings of [18].

The infiltration rate was observed to increase with different tillage treatments. The increase in the initial infiltration rate by different tillage treatments could be due to the increase in the porosity through the aggregation of the surface soil. The same results obtained by [11]. [15] reported that the infiltration rate decreases during irrigation with time, for all treatments the infiltration rate decreases with time until it reached a constant rate as the time elapsed (Fig. 2).

Effect of Tillage Treatments and Sowing Methods on Some Crop Parameters

Plant populations (plants/m^2) as affected by different treatments for the two seasons are shown in tables (7) and (8). The analysis of variance indicated no significant differences between the treatments and their interaction effects in the two seasons (table 9). The disc plough treatment resulted in the highest population for both seasons, followed by the heavy disc harrow and no-tillage treatment. The plant population in the first season was higher than the second one (Fig. 3).

TABLE 7. Effect of tillage treatment on yield and yield Components of Wheat

Season	**(1)**				**Season**	**(2)**			
Tillage	**Plants/ m^2**	**Gr. yield (ton/ha)**	**TBY ton/ha)**	**HI%**	**Tillage**	**Plants/ m^2**	**Gr. yield (ton/ha)**	**TBY (ton/ha)**	**HI%**
P1	496^{a}	4.45^{a}	14.83^{a}	31.0^{a}	P1	466^{a}	3.77^{a}	12.42^{a}	30.6^{a}
P2	476^{a}	3.61^{ab}	13.63^{b}	26.4^{b}	*P2*	454^{a}	3.56^{a}	11.33^{ab}	31.5^{a}
P3	470^{a}	3.11^{ab}	12.55^{c}	24.4^{c}	*P3*	408^{a}	2.62^{b}	10.42^{ab}	24.9^{b}

Means followed by the same letter(s) are not significantly different at alpha = 0.05 according to Duncan's Multiple Range Test (DMRT).

TABLE 8. Effect of sowing method on yield and yield Components of Wheat

Season	**(1)**				**Season**	**(2)**			
Sowing Method	**Plants/ m^2**	**Gr. yield (ton/ha)**	**TBY (ton/ha.)**	***HI%***	**Sowing Method**	**Plants/ m^2**	**Gr. yield (ton/ha)**	**TBY (ton/ha.)**	**HI%**
S1	483^{a}	3.65^{a}	13.92^{a}	25.8^{a}	S1	425^{a}	3.22^{a}	11.39^{a}	28.0^{a}
S2	478^{a}	3.78^{a}	13.42^{a}	28.0^{a}	***S2***	461^{a}	3.48^{a}	11.39^{a}	29.9^{a}

The highest plant population recorded by the disc ploughing treatment and the lowest plant population was given by the no-tillage treatment for the two seasons and this could be due to the relatively proper pulverization of the soil. No difference between the two sowing methods effect on plat population. Dancan's Multiple Range Test showed that there was no significant difference between the effect of two treatment interaction, on plant population (table 8).

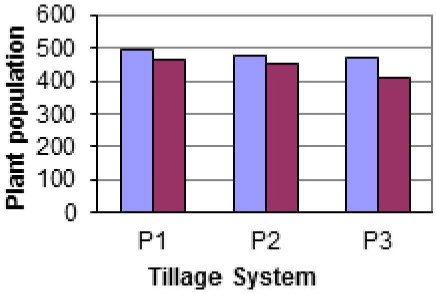

Fig.3. Effect of tillage treatments on plant population

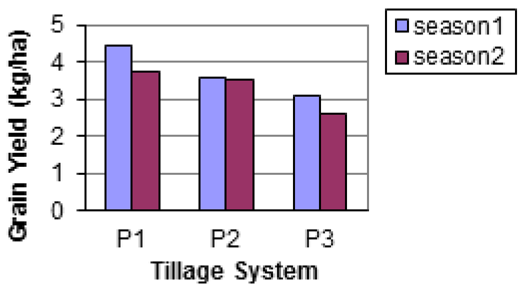

Fig.4. Effect of tillage treatments on crop grain yield

Statistical analysis showed significant differences between the tillage treatments effect on crop grain yield for the two seasons (table 9). The highest average crop yield of the two seasons was recorded by the disc plough tillage treatment as 4.11 ton/ha, while the lowest average crop yield was recorded by no-tillage treatments 2.87 ton/ha (Fig. 4). The highest grain yield obtained by the disc plough treatment could be due to greatest working depth as well as the higher plant population and moisture content. These results are in line with the finding of [20] and [19]. Duncan's Multiple Range Test showed that no significant differences between the different sowing methods in both seasons (table 8). Sowing by seed drill machine recorded an average yield of 3.44 ton/ha, while manual broadcasting plus ridging, recorded 3.63 ton/ha of the two seasons. The analysis of variance indicated no significant differences between the interaction effects of tillage and sowing methods treatments in the two seasons. The results of biomass yield as affected by tillage treatments and sowing methods for the two seasons showed significant differences between treatments for ANOVA and Duncan's Multiple Range Test. The disc plough recorded the highest biomass in both seasons followed by heavy disc harrow and no-tillage treatments. The average yield was increased by 14% for disc plough and by 5% for heavy disc harrow compared to no-tillage treatment. Harvest index results for the two seasons as affected by tillage treatments and sowing methods are shown in tables 7 and 8. The analysis of variance indicated significant differences (5% level) between the tillage treatments in the first season highly significant differences at 1% level in the second season (table 9). The highest average harvest index was recorded by the disc ploughing treatment as 30.8% while no-tillage treatment resulted in the lowest average harvest index as 24.6%. The two sowing methods showed insignificant effect on harvest index in both seasons (tables 8, 9). The average recorded harvest index was 26.9% and 29.0% for S_1 and S_2 respectively. Generally the results of the first season for most of the measured parameters were higher than the second season values.

TABLE 9. ANOVA table of wheat yield and yield components (Season 1 and 2)

D. Variable	**F – Calculated**				**F – Tabulated**	
Season 1	Plant/m^2	Grain Yield (Ton/ha.)	Biomass (Ton/ha.)	HI%	5%	1%
Tillage	0.43	7.84**	4.56	5.57*		
Sowing	0.05	0.21	0.65	2.71		
Tillage x sowing	0.45	0.76	0.38	1.19		
Season 2	**F – Calculated**				**F – Tabulated**	
	Plant/m2	Grain Yield (Ton/ha.)	Biomass (Ton/ha.)	HI%	5%	1%
Tillage	2.72	8.52**	2.31	8.37**		
Sowing	2.78	0.65	0.50	1.66		
Tillage x sowing	1.07	0.48	0.40	0.09		

IV. Conclusions

The following conclusions can be drawn from the results of this study,

1. The moisture content (db%) of all treatments increased with depth and then decrease. The highest average moisture content, slippage (%) and fuel consumption rate in (Li/ha) were recorded by the disc plough while the seed drill machine recorded the highest field efficiency and field capacity
2. The highest plant population/m^2, crop yield, total biomass and harvest index were recorded by disc ploughing treatment.

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